



ELIZADE UNIVERSITY, ILARA-MOKIN,
ONDO STATE, NIGERIA
DEPARTMENT OF
MECHANICAL ENGINEERING

SECOND SEMESTER EXAMINATIONS

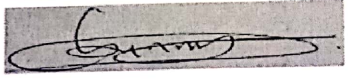
2017/2018 ACADEMIC SESSION

COURSE: MEE 506– Applied Thermodynamics II (3 Units)

CLASS: 500 Level Mechanical Engineering

TIME ALLOWED: 3 Hours

INSTRUCTIONS: Answer any **FOUR** questions


HOD'S SIGNATURE

Date: July/August, 2018

Question 1

- a) Briefly answer the following questions:
- What do you mean by compressor?
 - Why is the clearance volume provided in a reciprocating compressor?
- b) A single-stage, single-acting reciprocating compressor has a bore of 210 *mm* and a stroke of 320 *mm*. It runs at a speed of 550 *rpm*. The clearance volume is 5 % of the swept volume and the polytropic index is 1.35 throughout. Intake pressure and temperature are 99 *kN/m²* and 20 ⁰*C*, respectively, and the compression pressure is 570 *kN/m²*. Determine,
- the Free Air Delivered (FAD) in *m³/min* (free air conditions 101.325 *kN/m²* and 15 ⁰*C*)
 - the volumetric efficiency referred to the free air conditions
 - the air delivery temperature
 - the cycle power
 - the isothermal efficiency, neglecting clearance

Question 2

- a) Briefly answer the following questions:
- Mention four (4) usage of compressed air?
 - What is the use of inter-cooler in a 2-stage air compressor?
- b) A four-stage, single-acting reciprocating compressor running in an atmosphere at pressure and temperature of 1.013 *bar* and 15 ⁰*C*, respectively, has a free air delivery at 2.8 *m³/min*. The suction pressure and temperature are 0.95 *bar* and 30 ⁰*C* respectively. Calculate the indicated power

required, assuming complete inter-cooling, $n=1.35$, and that the machine is designed for minimum work. The delivery pressure is to be 85 bar .

- c) A single-stage, double-acting air compressor has Free Air Delivery (FAD) of $13.5 \text{ m}^3/\text{min}$ measured at 1.013 bar and 15°C . The pressure and temperature in the cylinder during induction are 0.95 bar and 30°C respectively. The delivery pressure is 6.5 bar and the index of compression and expansion, $n=1.35$. Calculate:
- the indicated power required
 - the volumetric efficiency. The clearance volume is 5% of the swept volume

Question 3

- a) Briefly answer the following questions:
- List four (4) classifications of boilers.
 - Give four (4) applications of boilers.
- b) A coal fired boiler installation is seen to have operating parameters as given in Table 1.

Table 1: Operating parameters of a coal fired boiler

| S/N | Operating Parameter | | Value | Unit |
|-----|----------------------|--|--------|------------------------|
| | Symbol | Description | | |
| 1. | m_f | Mass of fuel per kg of fuel | 1.00 | kg/kg of coal |
| 2. | m_{steam} | Mass of steam generated per kg of fuel | 3.91 | kg/kg of coal |
| 3. | m_{dfg} | Mass of dry flue gas per kg of fuel | 7.54 | kg/kg of coal |
| 4. | f_{co} | Percentage by volume of CO present in flue gases | 0.55 | % |
| 5. | f_{co_2} | Percentage by volume of CO ₂ present in flue gases | 14.00 | % |
| 6. | f_c | Fraction of carbon present per kg of fuel | 0.4165 | |
| 7. | T_a | Temperature of air entering combustion chamber | 31 | $^\circ\text{C}$ |
| 8. | T_g | Temperature of flue gases | 190 | $^\circ\text{C}$ |
| 9. | c_{pg} | Specific heat of dry flue gases | 0.23 | kcal/kg |
| 10. | $c_{v_{coal}}$ | Calorific value of fuel | 3501 | kcal/kg |
| 11. | $\Delta h = h - h_w$ | Difference between enthalpy of final steam produced and enthalpy of feed water | 636.87 | kcal/kg |
| 12. | Q_{carbon} | Heat loss due to incomplete combustion of one kg of carbon | 5744 | kcal/kg |

Determine,

- Total heat available due to fuel burning.
- Heat used for generation of steam.
- Heat lost due to incomplete combustion.
- Heat loss to dry flue gases.
- Other heat losses.

Question 4

a) Briefly answer the following questions:

- i. What is the main application of steam nozzle in steam turbine?
- ii. State two contributions to frictional losses in nozzles.

b) In a nozzle, steam expands from 12 *bar* and 300 °C to 6 *bar* with flow rate of 5 *kg/s*. Determine,

- i. throat and exit area if exit velocity is 500 *m/s* and velocity at inlet to nozzle is negligible.
- ii. Also find coefficient of velocity at exit.

Note: Coefficient of velocity is the ratio of actual velocity of fluid at nozzle exit to the velocity at exit considering isentropic flow through nozzle.

Question 5

a) Briefly answer the following questions:

- i. List four (4) classifications of steam engine.
- ii. Draw and label a schematic illustration of a simple steam engine plant?

b) A double acting steam engine has bore of 32 *cm* and stroke to bore ratio of 2.1 with cut-off occurring at 42 % of stroke. Steam enters the engine cylinder at 8 *bar* and exhausts at 0.15 *bar*. Engine runs at 200 *rpm*. Neglecting clearance volume and considering diagram factor of 0.6 determine the indicated horse power.

c) In a single acting steam engine, steam is admitted at 15 *bar*, 200 °C and exhausts at 0.75 *bar* with cut-off occurring at 25 % of stroke. Engine produces 150 *hp* at 240 *rpm*. The mechanical efficiency of engine is 85 %, diagram factor is 0.7, brake thermal efficiency is 20 % and stroke to bore ratio is 1.5. Determine,

- i. the cylinder dimensions, and
- ii. the specific steam consumption.

Note: Neglect the cross-section area of piston rod and clearance volume.

Question 6

a) Briefly answer the following questions:

- i. List four (4) classifications of steam turbine.
- ii. State four (4) means energy is lost in steam turbines.

b) A steam engine operates with steam being supplied at 0.2 *MPa*, 250 °C and expanding up to 0.3 *bar*. Steam is finally released out at 0.05 *bar*. Determine,

- i. Draw the modified Rankine cycle
- ii. the modified Rankine cycle efficiency, and
- iii. compare it with the efficiency of Carnot cycle operating between given limits of pressure.

Note: Neglect feed pump work.